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COLOR IMAGE SENSOR WITH ENHANCED CALORIMETRY AND METHOD FOR MAKING SAME
[CAPTEUR D'IMAGE COULEUR A COLORIMETRIE AMELIOREE ET PROCEDE DE FABRICATION]

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TITLE	(54):	Color Image Sensor with Enhanced Colorimetry and Method for Making Same
FOREIGN TITLE	[54A]:	Capteur d’image couleur à colorimétrie ameliorée et procédé de fabrication

Description /1[*]

The invention concerns electronic image sensors, and especially very small-sized sensors with dimensions that make it possible to produce miniature cameras such as those that may be incorporated into a portable telephone.

For this type of application, it is necessary to make the entire camera by methods that are as economical as possible so that the apparatus is not prohibitively costly, since it is intended, in principle, for sale to the general public.

To achieve this result, on the one hand, if possible, the image sensor and the electronic processing circuits are made on the same monocrystalline semiconductor substrate (in principle silicon), and, on the other hand, the various layer deposits, etchings, heat-processing operations, etc. as far as possible are made collectively on a general substrate in the form of a wafer comprising numerous identical sensors, before cutting the wafer into individual sensors. Typically, a silicon wafer will comprise several thousands of individual chips each constituting the core of an image sensor and therefore a camera.

However, the methods of making color image sensors and the structures thereof that have been proposed up to now are not entirely satisfactory from the viewpoint of the manufacturing quality/cost ratio: no manufacturing method has been found that is at the same time sufficiently simple, industrially efficient, and compatible with increasingly higher

[*]Numbers in the margin indicate pagination in the foreign text.

requirements for the quality of the image provided. In particular, one of the requirements is the quality of the colorimetry, determined in particular by the sharp separation of light beams between adjacent photosensitive points covered with filters of different colors.

A color image sensor is classically made as follows: the process starts with a silicon wafer on the front face of which operations of masking, impurity implantation, deposition of various temporary or permanent layers having different compositions, etching of these layers, heat treatments, etc. are performed; these operations make it possible to define a matrix of photosensitive dots and electric signal-processing circuits associated with these dots; then colored filtering layers, /2 which are individually etched in order to define a matrix pattern, are deposited on the front face of the silicon wafer: the matrix comprises, in rows and columns, groups of three or four juxtaposed filters of different colors for each image dot of the sensor. Each elementary filter is located above a respective photosensitive zone receiving the light of only one color. The immediately adjacent filters, above immediately adjacent photosensitive zones, have different colors. Finally, the silicon wafer is cut into chips each constituting an individual color image sensor.

The colored filters are placed above insulating, conducting, and semi-conducting layers that have served to define the photosensitive dots and their interconnections. They are at a distance of several micrometers above the silicon zones which convert the light photons into electrons. This vertical distance is not negligible relative to the horizontal

dimensions of a photosensitive dot and induces the following phenomenon: photons having crossed a colored filter do not immediately reach the photosensitive zone corresponding to this filter; in the path that remains to be traveled after the colored filter, they may be scattered, undergo refractions, reflections, etc. The result of this is that part of the photons may reach an adjacent photosensitive zone. If monochromatic light were to be used in the process, this would not be very important: the result would be a slight loss of spatial resolution which would affect only the image zones containing high spatial frequencies. However, in a color camera, the problem is much more critical because even image zones having only low spatial frequencies (for example a uniformly red-colored image zone) are greatly affected: the color is systematically deteriorated because the pixels corresponding to the other colors systematically receive a fraction of the light flux that is not intended for them. The quality of the colorimetry is therefore particularly affected by the scattering of light in the interval that separates the colored filter and the photosensitive zone that corresponds to it.

This problem is particularly critical in CMOS image sensor technologies. This technology, based on photodiodes as photosensitive elements, is increasingly used because it makes it possible to obtain the image sensor (photosensitive dot matrix) and the associated /3
signal-processing and control circuits on the same integrated circuit chip. This technology requires numerous dielectric and metal layers to be deposited above the silicon level at which the photosensitive zones proper

are made. The result of this is that the colored filters deposited above this stack are particularly distant from the photosensitive zones, and the colorimetry deterioration phenomenon is particularly marked. In this case, the height of the stack easily reaches around ten micrometers.

The object of the present invention is to propose a method of making a color image sensor and a structure thereof that noticeably improve the colorimetric quality of the images obtained, at the cost of a small but acceptable increase in the complexity of making the sensor, without impairing other qualities such as sensitivity in weak light and reduced bulk.

For this purpose, the invention proposes a method for making a color image sensor, comprising:

- forming, on the front face of a semi-conducting wafer, a series of active zones comprising image detection circuits and each corresponding to a respective image sensor, each active zone comprising photosensitive zones covered with insulating and conducting layers permitting the collection of electrical charges generated in the photosensitive zones,

- transferring the wafer by its front face against the front face of a supporting substrate,

- eliminating the major part of the thickness of the semi-conducting wafer, leaving a very fine semi-conducting layer on the substrate, this fine semi-conducting layer comprising the photosensitive zones,

- and, finally, depositing and etching colored filters on the semi-conducting layer thus thinned.

It is understood that with this method the colored filters are no longer above the stack of insulating and conducting layers that may have been deposited (by CMOS technology or any other technology) on the photosensitive zones during the production of the semi-conducting wafer. Quite the reverse, the filters are placed above the /4 photosensitive zones, opposite the insulating and conducting layers which are then on the other side of the photosensitive zones. This means that, in using the sensor in a camera, the light will pass through the colored filters and directly reach the photosensitive zones without having to pass through the stack of insulating and conducting layers.

This production method requires transferring the semi-conducting wafer onto a substrate and thinning the semi-conducting wafer. Transferring and thinning techniques are being mastered better and better so that the excess cost of the operation will be acceptable for a remarkably improved image quality.

The size of the sensor (since very small-sized sensors are desired) is not deteriorated and its sensitivity under weak light is even improved.

The image sensor according to the invention therefore essentially comprises, on a supporting substrate, a superimposed unit comprising, on the one hand, a very thin semi-conducting layer in which a matrix array of photosensitive zones is formed and, on the other hand, a stack of insulating and conducting layers enabling the collection of the electrical charges generated by light in the photosensitive zones, and it is characterized by the fact that colored filters are deposited on this

superimposed unit, on the very thin semi-conducting layer side, so that the light passes in the order given, through the colored filters and then the photosensitive semi-conducting zones, then reaching the stack of insulating and conducting layers without encountering a network of conducting layers before reaching the network of photosensitive zones.

The semi-conducting wafer can be transferred by gluing, classic soldering, anodic bonding, or simple molecular adhesion (very high force of contact between two surfaces having great planeity).

After being transferred onto the substrate and before the colored filters are deposited, the wafer can be thinned in many different ways: thinning by lapping, chemical thinning, combination of both types of thinning (first mechanical then chemical finishing, or mechanical machining in the presence of chemical products); it is also possible /5
to perform thinning by preliminary embrittlement of the wafer at the level of the desired cutting plane, in particular by deep hydrogen implantation in the desired cutting plane. In the latter case, the hydrogen implantation is performed at a shallow depth in the semi-conducting wafer before the transfer of the wafer onto the substrate. The thinning is then performed by heat treatment which dissociates the wafer at the level of the implanted cutting plane, leaving a thin semi-conducting layer in contact with the substrate.

The very great thinning of the wafer reduces its thickness from several hundreds of micrometers before transfer onto the substrate to 3 to 20 micrometers after transfer onto the substrate.

Preferably, the integrated circuit chip corresponding to an individual sensor comprises, at the same time, a matrix of photosensitive elements, matrix control circuits, and associated image-processing circuits receiving signals coming from the photosensitive elements of the active zone. The circuits thus associated with the matrix are preferably masked against light by a layer of aluminum, only the matrix being exposed to light.

In a particular embodiment, metallized vias arranged with the same geometry as connection pads formed on the semi-conducting wafer around each active zone (therefore on the periphery of each individual image sensor), are formed on the supporting substrate, prior to the transfer of the semi-conducting wafer. During the transfer, the connection pads come into contact with the metallized vias, and connections to the exterior may be made behind the supporting substrate. The image sensors may also be tested on the wafer, before being cut into individual sensors after the operations of transferring, thinning, depositing, and etching of the colored filters.

The semi-conducting wafer is preferably made of silicon. The supporting substrate may be made of silicon. It may also be made of another material, the expansion coefficient of which is compatible with that of the silicon so as not to create excessive stresses during the temperature variations to which the wafer/substrate structure is subjected.

Other features and advantages of the invention will appear from /6 reading the following detailed description, made with reference to the appended drawings, in which:

- Fig. 1 shows a classic CMOS color image sensor;
- Fig. 2 shows a color image sensor according to the invention;
- Fig. 3 shows a particular embodiment of the sensor according to the invention with a transparent protective layer above the colored filters;
- Fig. 4 shows a possible mode of connection of the sensor with the exterior, by metallized access wells formed in the silicon wafer before transfer onto the supporting substrate;
- Fig. 5 shows another possible mode of connection with metallized vias formed in the supporting substrate before transfer of the wafer;
- Fig. 6 shows yet another possible mode of connection with metallized access wells formed after the thinning operation;
- Fig. 7 shows a version of an embodiment of the sensor according to the invention, in which a definitive substrate is transparent, the colored filters being located between the transparent substrate and the thinned silicon layer;
- Figs. 8 to 12 show the different steps of making the sensor in a practical example corresponding to the embodiment of Fig. 5.

Fig. 1 succinctly recalls the principle of a prior art color image sensor. The sensor is made on a silicon substrate 10, the thickness of which is several hundreds of micrometers, this thickness being that of the silicon wafer on which a multiplicity of individual image sensors are made simultaneously.

The image detection circuits (matrix of photosensitive dots, transistors, and interconnections) are produced on one face of the silicon wafer, which may be called the front face and which is the upper face in Fig. 1. The production involves, on the one hand, various operations /7 of diffusion and implantation in the silicon, from the upper face of the wafer, to form especially photosensitive zones 12, and, on the other hand, successive procedures of depositing and etching conducting layers 14 and insulating layers 16 forming a stack above the photosensitive zones 12. The insulating and conducting layers are part of the image detection circuits and permit the collection of electrical charges generated in the photosensitive zones by an image projected onto the sensor.

Above the stack of conducting and insulating layers, there is a matrix of colored filters 18 so that a particular colored filter 18 corresponds to each individual photosensitive zone 12, the photosensitive zone 12 receiving, in principle, only the light that has passed through the corresponding colored filter. The adjacent photosensitive zones correspond to different colors, for example red, green, blue or cyan, magenta and yellow, and a trichromatic image dot corresponds to three (sometimes four) adjacent colored filters.

During use, the light modulated by the image to be detected reaches the filters, crosses the conducting and insulating layers and reaches the photosensitive zones.

The insulating layers are, in principle, quite transparent, but the conducting layers are most often opaque and reflecting; the photosensitive

zone proper therefore is not placed below portions of conducting layers and the light reaches the photosensitive zone directly after passing into the colored filters and the insulating layers.

However, the multiplicity of superimposed insulating layers and the presence of conducting layers, most often made of aluminum, on the sides creates multiple refractions and reflections that become a part of the light coming from a colored filter to the photosensitive zones that do not correspond to this filter. Even a low percentage of light thus deflected creates a great degradation of the colorimetrical performance of the sensor.

Fig. 2 shows the sensor according to the invention. It comprises a substrate 20 that first of all bears a superimposed set of two groups of layers. One of the groups which, in the embodiment of Fig. 2, /8
rests directly on the substrate 20, is a stack of conducting layers 14 and insulating layers 16, similar to the stack of conducting and insulating layers 14 and 16 of Fig. 1 but arranged in reverse. This stack may have a thickness of about ten micrometers. The second group of layers comprises a very thin silicon layer 30 (around 3 to 20 micrometers thick) in which photosensitive zones 12 have been formed by implantation and/or diffusion of impurities. The conducting and insulating layers 14 and 16 define electrical circuits permitting the collection of electrical charges generated by light in the photosensitive zones 12. The unit comprising zones 12, layers 14, and layers 16 is similar to that of Fig. 1, but is positioned upside-down, that is, turned towards the bottom.

Colored filters 18 are deposited onto the very thin silicon layer 30, opposite the conducting and insulating layers, so that the light passes in the order through the colored filters, then into the photosensitive silicon zones, then possibly into the insulating and conducting layers. It will be seen that the embodiment of Fig. 8 comprises a stack different from that of Fig. 2 in the sense that the substrate, which is then transparent, first bears the colored filters, then the very thin silicon layer, then the stack of insulating and conducting layers, but the colored filters are still opposite the stack of insulating and conducting layers adjacent to the very thin silicon layer, contrary to what is shown in Fig. 1.

Consequently, in general, there is no network of connecting electric conductors above the photosensitive zones 12, between the plane of these zones and the plane of the colored filters. All the etched conducting networks that assure the operation of the photosensitive matrix are below the photosensitive zones and the colored filters that cover them.

The photons that pass through a colored filter 18 are absorbed in the very thin silicon layer 30 and produce electrical charges collected in the photosensitive zone 12 (in practice a photodiode) located below the colored filter. The electrical charges are collected by the conductors of the stack located below the photosensitive zone. This stack of insulating and /9
conducting does not constitute an obstacle to the photons and therefore does not create any deflection toward the adjacent photosensitive zones.

Only the photons not absorbed by the silicon layer 30 get lost in these layers.

The method of making the sensor of Fig. 2 consists on the whole of preparing a silicon wafer exactly as in the case of producing a traditional sensor such as that of Fig. 1, except for the positioning of the colored filters. Then this wafer is attached to another wafer, or supporting wafer, which will constitute the substrate 20. In this operation, the front face of the silicon wafer bearing the photosensitive circuits is applied against the supporting wafer (which may be designated as 20 since it constitutes the substrate 20 of Fig. 2). At this stage, the work is performed on wafers (for example, 150 to 300 mm in diameter) and not on individual sensors.

It is preferable to make the front face of the silicon wafer properly plane before the transfer operation, since the operations of depositing and etching of the stack of insulating and conducting layers 14, 16 have created a relief on this face. This "planarization" is classically performed by depositing an insulating layer filling the hollows of the relief. This planarization layer does not need to be transparent.

The silicon wafer can be transferred onto the supporting wafer 20 by several means, it being possible for the simplest means to be quite simply holding the wafer by molecular adhesion, the great planeity of the surfaces in contact generating very high contact forces. Gluing is also possible. As will be seen further below, it is also possible to set up a mechanical and electrical bond between contact pads of the silicon wafer and

corresponding contact pads of the supporting wafer 20 by the intermediary of conducting metal or organic bosses.

After the silicon wafer has been transferred by the front face to the supporting wafer, the major part of the thickness of the silicon wafer is eliminated so as to leave only a thickness of about 8 to 30 micrometers, including the thickness of the stack of layers. That which remains of the silicon wafer is only a superimposition of a few micrometers (from 5 to 10 for example) for the stack of layers 14, 16 and about 3 to 20 micrometers for the remaining silicon thickness, including the photosensitive /10
zones 12. The remaining thickness is layer 30 of Fig. 2.

The thinning operation can be performed by mechanical machining (lapping) terminated by chemical machining, or by mechanical/chemical machining, or by chemical machining alone, or again by a particular method of separation necessitating a preliminary implantation of an embrittling impurity into the plane that will demarcate the thinned silicon layer.

In the case of this separation by implantation of impurities, it is necessary to perform the implantation before transferring the silicon wafer to the supporting wafer. In fact, the implantation is performed by the front face of the silicon wafer, on the entire surface of the wafer and at a depth that will define the cutting plane. The preliminary implantation is preferably hydrogen implantation. It can be performed at different stages of producing the wafer, but the separation of the thickness of the wafer along the implanted cutting plane can be performed only when the silicon wafer has been attached to the supporting wafer. This

separation is performed essentially by a heat-processing operation generating stresses that divide the wafer into two along the pre-implanted cutting plane.

The upper surface of the thinned silicon layer 30 can be treated (fine lapping, chemical cleaning, mechanical/chemical polishing, etc.) in order to eliminate the surface defects, after which the colored filters can be deposited and etched, leading to a multiple-sensor wafer, the general structure of which is that of Fig. 2. If it is desired, before depositing the colored filters it is possible to deposit one or more additional layers, in particular passivation layers, anti-reflection layers, and other layers, for example layers needed for electrical activation of the doped silicon layers (electrical polarization layers). These additional layers are designated as reference number 19 in Fig. 2 and are not shown in the other figures.

Fig. 3 shows an embodiment in which, starting from Fig. 2, there is also a transparent layer 35 on the entire surface of the sensor. This layer 35, made of glass or transparent plastic material, is applied closely against the surface that bears the filters. It does not absorb /11
photons well and protects the surface of the colored filters and the silicon below. This layer may have a thickness of a few micrometers to a few hundred micrometers. A planarization layer may be deposited on the colored filters before layer 35 is deposited in order to make the irregularities of relief due to the colored filters disappear.

It must be noted here that the transparent layer 35 may be placed on the unit supported by the substrate 20 while the latter is still in wafer form (for example, 6 or 8 inches in diameter) bearing numerous individual image sensors.

Figs. 4 to 7 show various ways of making contacts between the sensor and the exterior, for example in order to convey control signals and a power supply and collect the electronic signals representing the image detected by the sensor. These contacts are again obtained there while working on the wafer, before the wafer is divided into individual sensors.

In the embodiment of Fig. 4, access wells 50 have been created in the front face of the silicon wafer (the face turned toward the bottom on Fig. 4), before transfer onto the supporting wafer, access wells 50 extending to a depth of 3 to 20 micrometers below the initial surface of the silicon, and extending more precisely exactly up to the depth at which the silicon wafer will be thinned.

The access wells thus hollowed out are located on the periphery of each individual sensor, the photosensitive active matrix zone ZA being surrounded by the series of wells 50 (the number of which may typically be 30 or 40 for an individual image sensor). The wells 50 are filled with a conducting material 52 (such as aluminum, copper, tungsten, etc.) that comes into contact, on the upper surface of the silicon wafer (the face turned downwards, in contact with the transfer substrate 20), with one or more conducting layers 14, more specifically with those layers that require contact with the exterior. Before filling the wells with the conducting material, it is

preferable to deposit an insulating layer (not shown) on the inner walls of the wells in order to insulate the contacts from the silicon layer 30.

During the thinning of the silicon after transfer, the major /12
part of the thickness of the silicon is eliminated until the metal 52 of the wells 50 is flush with the surface being thinned. This metal can then be used either directly or after additional depositing and etching operations in order to set up areas of contact with the exterior. It is possible to fix solder wires 54 (wire-bonding) there in order to transfer the sensor by the rear face against a printed circuit board, or on the contrary conducting bosses (for example indium beads 56) in order to obtain a transfer of the sensor by the front face against a printed circuit board (the "flip-chip" technique). In the latter case, obviously the printed circuit board is open at the position of the photosensitive matrix in order to let light pass. The wire-bonded version 54 and the boss version 56 are shown in the same Fig. 4 but obviously only one version can be used in the same sensor.

The colored filters 18 are positioned after the thinning of the silicon wafer.

Fig. 5 shows another embodiment for producing connection contacts with the exterior. In this embodiment, the supporting wafer 20 onto which the silicon wafer has been transferred has been previously prepared by the formation of conducting vias 60 passing through the entire thickness of the support. These vias open into both faces of the supporting wafer and they are arranged exactly opposite connection pads 22 formed on the front face

of the silicon wafer on the periphery of the active zone ZA of each individual image sensor.

When the silicon wafer is transferred onto the supporting wafer, the contact is thus made between the conducting vias 60 and the image detection circuits of the silicon wafer.

The conducting vias that open to the rear of the supporting wafer 20 permit all sorts of connections with the exterior such as wire-bonding, flip-chip, or other connections.

It will be noted that the connection is made while work is still being done on the silicon wafer and that it is possible to test image sensors on a wafer (probe test), which is very advantageous from the viewpoint of the test cost. This remark also applies to other modes of connection described here (Figs. 4, 6, 7).

Fig. 6 describes an embodiment in which the contact is /13
achieved by means of the following operations: after thinning the silicon wafer, access wells 70 are made not only in the thinned silicon layer 30 but also in some of the insulating layers 16, until they are flush with the conducting metal of a conducting layer 14 with which a connection with the exterior is desired. Then these wells 70 are metallized by depositing a conducting layer 72 that comes into contact with the layer 14 and that is flush with the surface of the thinned silicon layer 30 in order to form external contact pads 74.

Furthermore, in the embodiment of Fig. 6, it is also possible to provide for the operation of transferring the silicon wafer onto the supporting wafer

20 to be performed by soldering, preferably by means of conducting bosses 76 (indium beads for example), between conducting areas of a layer 14 of the silicon wafer, and conducting areas opposite the first areas, formed in the supporting wafer 20. Preferably, a filler resin 78 fills the space left free between the two wafers separated by the thickness of the bosses. This resin ensures the rigidity of the wafer during and after thinning.

It will be noted that in the embodiments of Fig. 4 to 6, the supporting substrate 20 may include active or passive circuit elements, in particular in the case where this substrate is made of silicon: integrated circuits may be formed in this substrate according to the classic technology for making integrated circuits, making it possible to integrate into the image sensor additional electronic functions other than those integrated in the silicon layer 30.

Fig. 7 shows a version of an embodiment presenting the following particular features: the colored filters 18, the thinned silicon layer 30, and the stack of conducting and insulating layers 14 are positioned in this order on a transparent substrate (made of glass or plastic material) 80. The image to be detected will be seen through the transparent substrate and will pass first through colored filters in order to reach the photosensitive zones of the thinned silicon layer 30; the color photons corresponding to the filters crossed will be absorbed in the layer 30; only the non-absorbed photons will be able to reach the stack of insulating and conducting layers 14, 16.

Connection pads 82, made by depositing metal and etching, and /14

forming part of a layer 14 or being in contact with a layer 14 are provided on the upper face of the unit (toward the top of Fig. 7).

In order to obtain this structure, it must be understood that a first transfer of the silicon wafer is made onto a supporting wafer 20, as in the embodiment of Fig. 2, followed by a second transfer of the structure of Fig. 2 onto a transparent substrate 80 and a total or partial suppression of the supporting wafer 20 which has served only as a temporary support.

For this purpose, starting from the structure of Fig. 2, made as already described above, the upper surface bearing the colored filters is planarized if necessary, in order to give it planeity compatible with a new transfer (in particular very high planeity if the transfer is performed by molecular adhesion). The planarization resin must be transparent because it will be on the path of the light upstream from the photosensitive zones.

The structure thus planarized is then transferred onto the substrate 80, the colored filters of the planarization layer being in direct contact with the transparent substrate 80. The major part or even the totality of the substrate 20 is eliminated by mechanical and/or chemical means, or by embrittlement by hydrogen implantation, for example as already explained. In this case, the hydrogen implantation in the supporting wafer 20 must have been performed prior to the first transfer of the silicon wafer onto the wafer 20, which assumes that, between the transfer onto the wafer 20 and the transfer onto the substrate 80, no operation is performed at

temperatures liable to cause a break at the level of the hydrogen implantation plane.

The temporary substrate 20 being eliminated, the connection pads 82 connected to the conducting layers 14 of the image detection circuits may be flush with the surface of the structure de Fig. 7.

Figs. 8 to 12 describe the embodiment detail in the case of the sensor of Fig. 5.

Fig. 8 shows the general structure of a silicon wafer on which classic techniques have been used to make the image detection circuits of a large number of image sensors, with photosensitivezones 12, covered by a /15
stack of conducting layers 14 and insulating layers 16.

Connection pads 22 are made on the upper surface of the wafer.

If the sensor were made by means of a classic technology, then a mosaic of colored filters would be deposited on the surface of the wafer.

According to the invention, no colored filters are deposited at this stage but the wafer is transferred by its front face onto a transfer substrate 20 that is shown in Fig. 9.

The substrate 20 is a wafer of the same diameter as the wafer 10 and a similar thickness in order to assure the rigidity of the structure while it is being made; it may also consist of another silicon wafer.

The transfer wafer comprises metallized vias 60, crossing its entire thickness, arranged with the same geometry as the input/output pads 22 formed on the silicon wafer 10.

At the upper part of each metallized via there is a conducting area 62 capable of coming into direct contact with a pad 22 of the wafer 10 during the transfer of the wafer 10 onto the substrate 20. At the lower part of each metallized via, there will also be a metallized area 64.

The transfer can also be performed after depositing a planarization layer serving to fill the relief features created on the front face of the silicon wafer by the operations of depositing and etching the stack of conducting and insulating layers. This planarization layer does not need to be transparent. It must leave the upper surface of the conducting pads 22 free.

Fig. 10 shows the wafer 10, overturned with its upper face downwards and in contact by this upper face with the upper face of the transfer substrate 20.

The transfer is performed by bonding or by molecular adhesion. It can even be performed by soldering the pads 22 to the areas 62.

After this transfer, the silicon wafer is thinned until only a thickness of 15 to 30 micrometers, including the thickness of the stack of layers 14, 16, is left. The remaining silicon thickness 30 /16
and the stack of layers 14, 16 contain all the image detection circuits (Fig. 11).

Finally, a mosaic of colored filters and possibly also a transparent film or even microlenses (Fig. 12) are deposited on the silicon layer 30 thus thinned.

The metallized areas 64 located behind the supporting substrate 20 serve as input/output pads of the sensor since they are electrically connected to the image detection circuits formed in the thinned silicon wafer 30. These pads may be used for a "wire-bonding" or preferably a "flip chip" type of connection. In the latter case, conducting bosses 66 are formed on the surface of the areas 64.

The structure can then be tested (the sensors are functional) and then cut into individual image sensors.

1. A method for making a color image sensor, comprising steps of:

- forming on the front face of a semi-conducting wafer (10), a series of active zones (ZA) comprising image detection circuits and each corresponding to a respective image sensor, each active zone comprising photosensitive zones (12) covered with conducting (14) and insulating (16) layers permitting the collection of electrical charges generated in the photosensitive zones,

- transferring the wafer (10) by its front face against the front face of a supporting substrate (20),

- eliminating a major part of the thickness of the semi-conducting wafer, leaving a very fine semi-conducting layer (30) comprising the photosensitive zones to remain on the substrate,

- and, finally, depositing and etching color filters (18) on the thinned semi-conducting layer.

2. The method according to Claim 1, wherein the transfer is performed by gluing, soldering, anodic bonding, or simple molecular adhesion.

3. The method according to one of Claims 1 and 2, wherein the thickness of the semi-conducting wafer after thinning is around 8 to 30 micrometers, including the thickness of the stack of conducting (14) and insulating (16) layers.

4. The method according to one of Claims 1 to 3, wherein metallized vias (60) arranged with the same geometry as connection pads (22) formed on the semi-conducting wafer around each active zone and coming into

contact with these pads during the transfer, are formed on the supporting substrate (20), prior to the transfer of the semi-conducting wafer, the metallized vias opening into the rear of the supporting substrate to form input/output pads (64) of the sensor.

5. An image sensor comprising, on a supporting substrate, a /18
superimposed unit comprising on the one hand a semi-conducting layer (30) in which a matrix array of photosensitive zones (12) is formed and, on the other hand, a stack of conducting (14) and insulating (16) layers permitting the collection of the electrical charges generated by light in the photosensitive zones, wherein colored filters are deposited on this superimposed unit, on the side of the very thin semi-conducting layer, so that the light to be detected passes in the order given through the colored filters, then the photosensitive semi-conducting zones, then the stack of insulating and conducting layers, without encountering a network of conducting layers, before reaching the matrix array of photosensitive zones.

6. The sensor according to Claim 5, wherein the semi-conducting layer containing the photosensitive zones has a thickness of around 3 to 20 micrometers above the stack of conducting and insulating layers.

7. The sensor according to one of Claims 5 and 6, wherein the supporting substrate comprises active or passive circuit elements.

8. The sensor according to one of Claims 5 to 7, wherein the semi-conducting wafer and the supporting substrate (20) are made of silicon.

9. The sensor according to one of Claims 5 to 8, wherein the supporting substrate comprises metallized vias (60) arranged with the same geometry as connection pads (22) formed on the silicon wafer around each active zone, and coming into contact with these pads during the transfer, the metallized vias opening to the rear of the supporting substrate in order to form input/output pads (64) of the sensor.

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5 pages of drawings appended

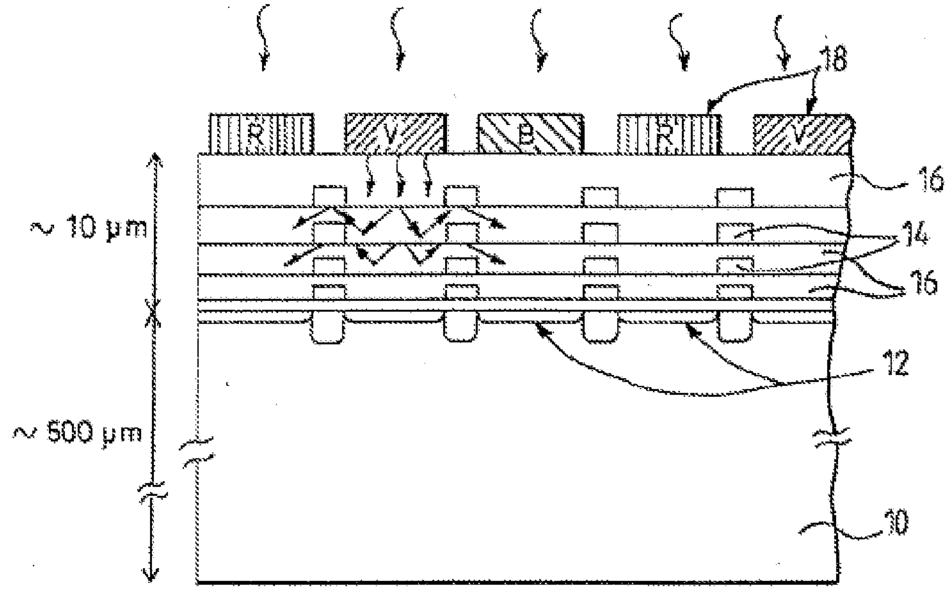
R
V
B
R
V
18
16
~ 10 µm
14
16
12
~ 500 µm
10

FIG.1

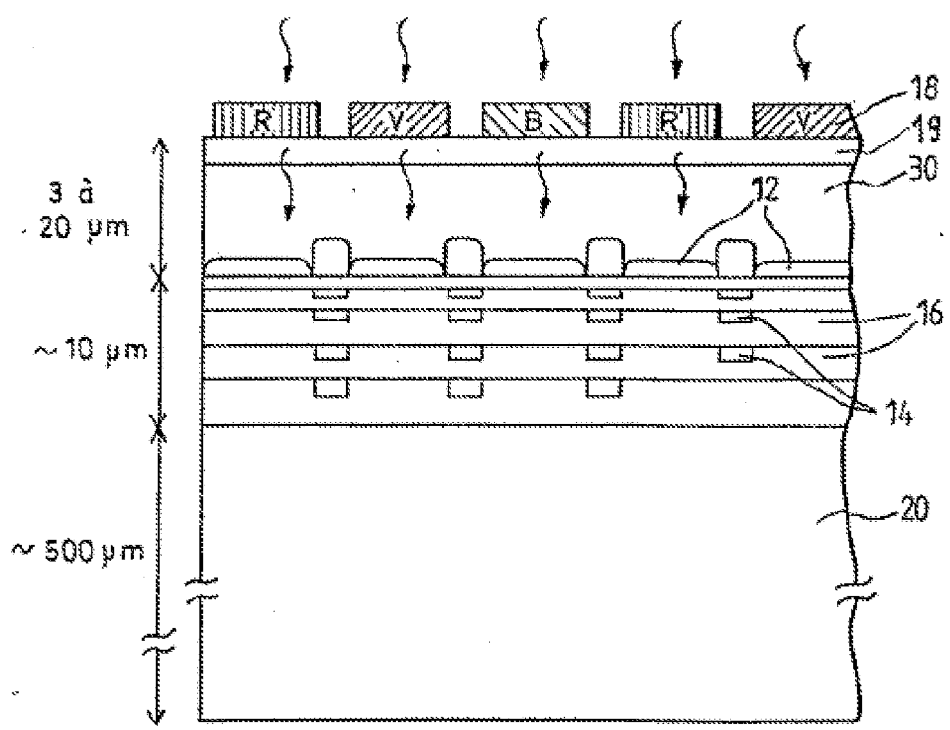
R
V
B
R
V
18
19
30
3 à
20 µm
12
~ 10 µm
16
14
~ 500 µm
20

FIG.2

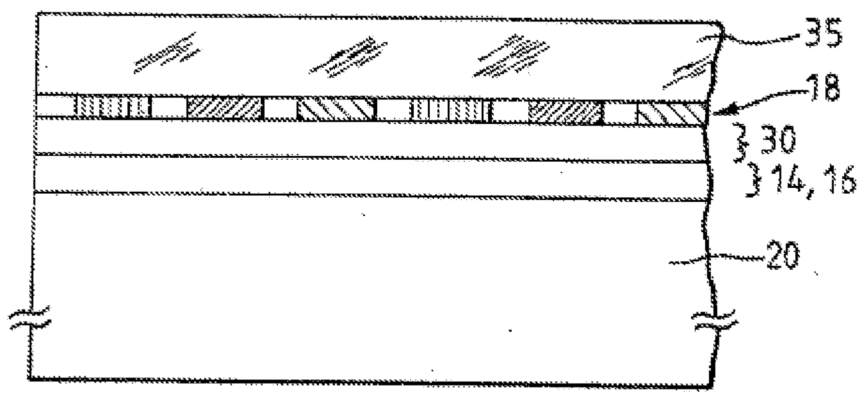

FIG.3

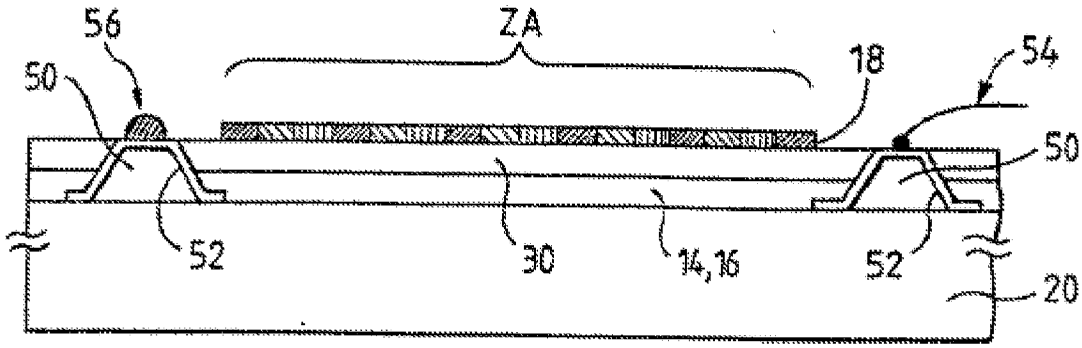

FIG.4

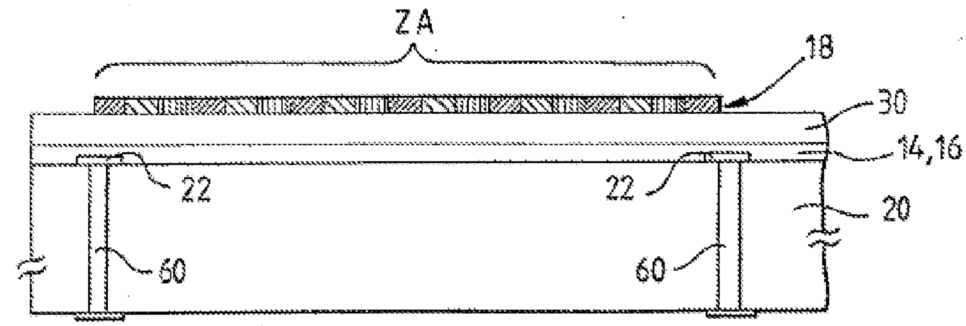

FIG. 5

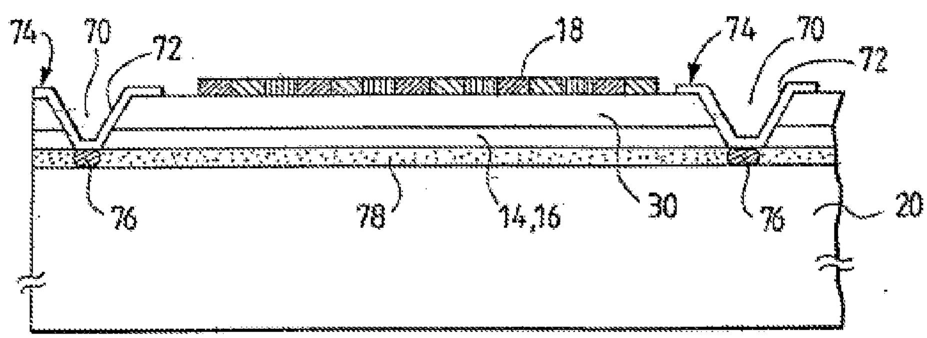

FIG.6

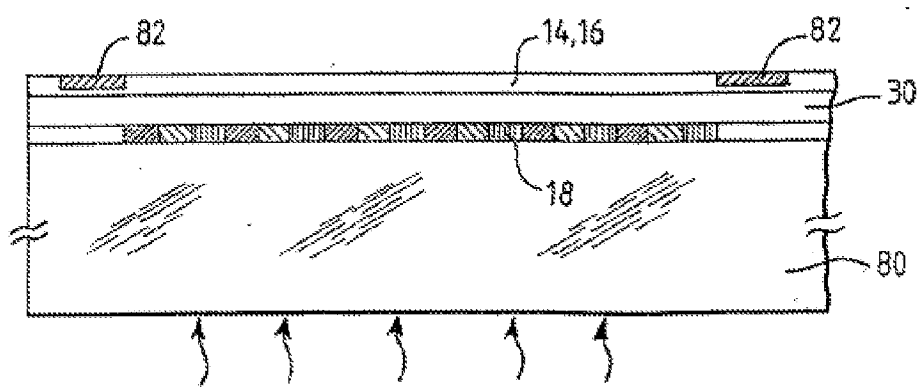

FIG.7

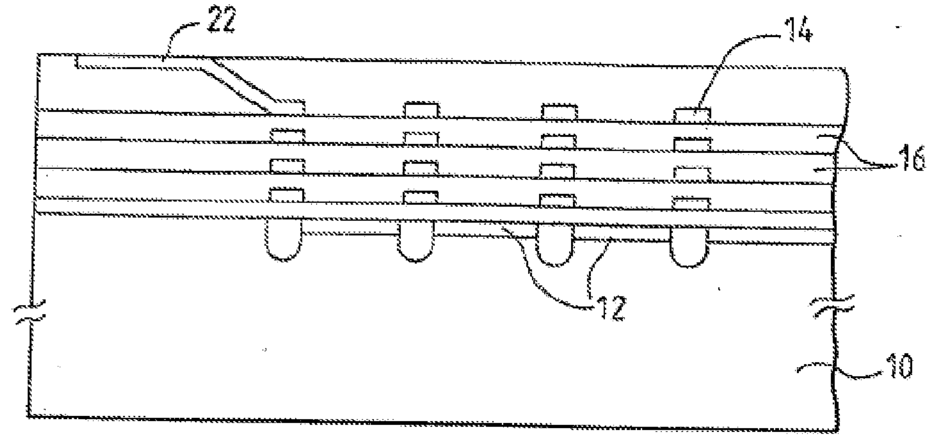

FIG.8

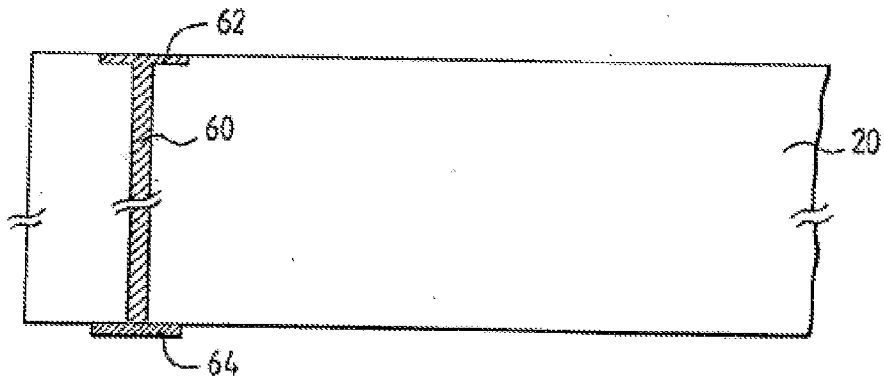

FIG.9

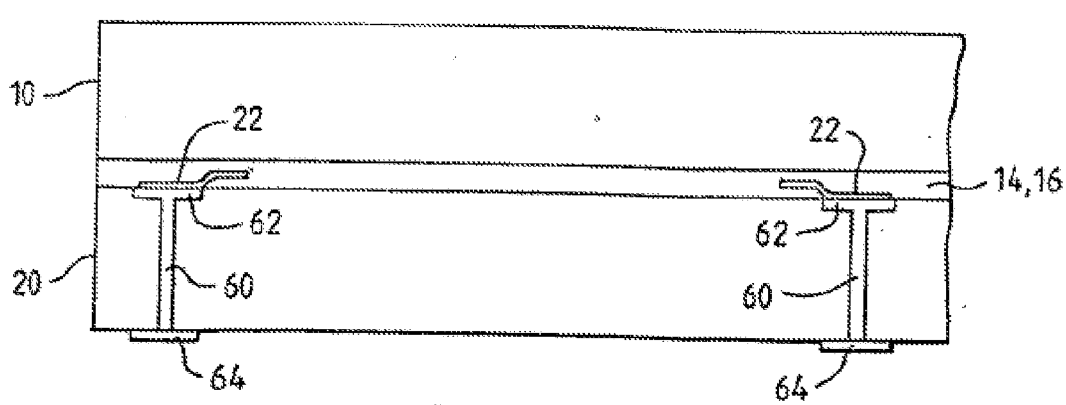

FIG.10

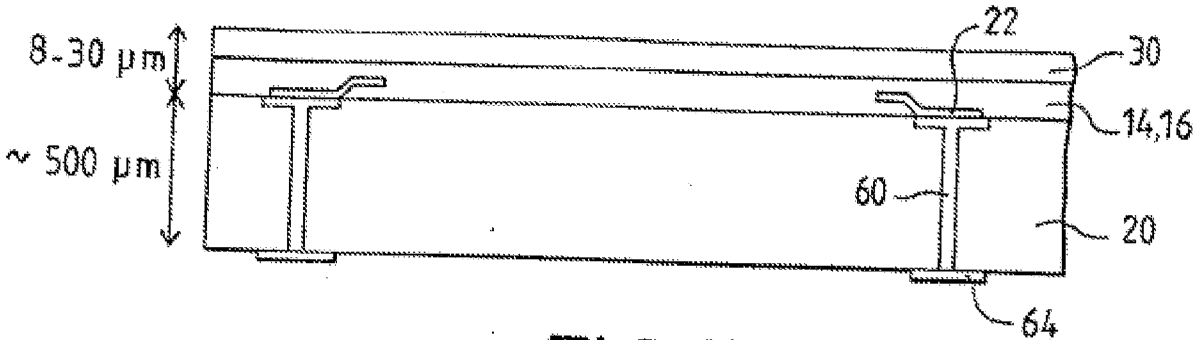

FIG.11

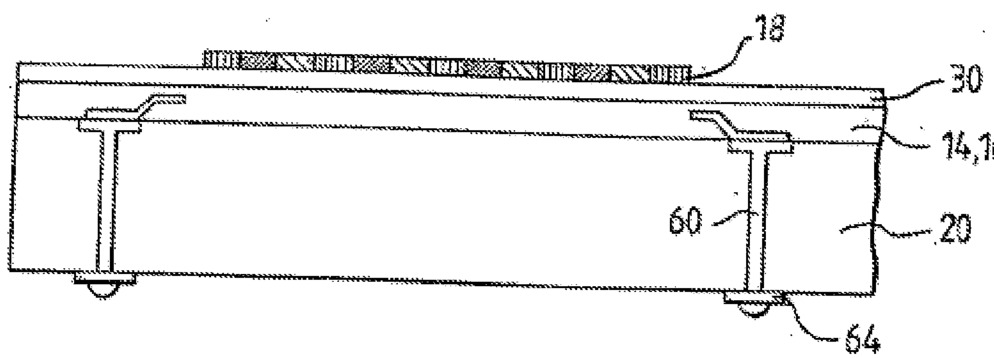

FIG.12